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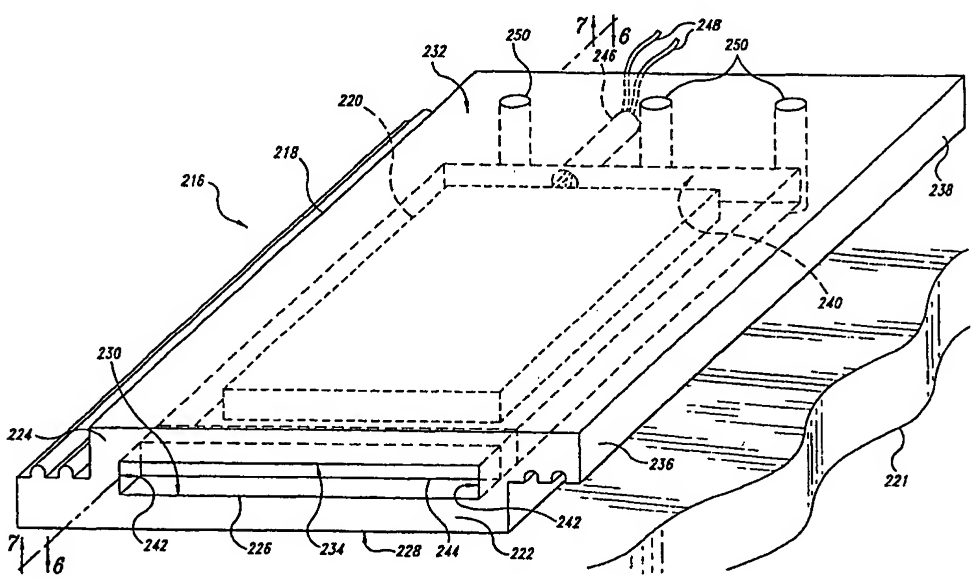

(57) Abstract

A photovoltaic roof tile for creating a roof covering over a roof substructure. In one embodiment, the roof tile includes a plate assembly and a photovoltaic cell. The plate assembly has a base portion for contacting the substructure and a face portion for protecting the photovoltaic cell. A compartment between the base portion and the face portion retains the photovoltaic cell, and the compartment is sealed to protect the photovoltaic cell from an external environment. The tile is configured to be coupled directly to the substructure and to overlap at least one adjacent tile for directing water down a slope of the substructure. The base portion and the face portion can be separate components that are sealed together to encapsulate the photovoltaic cell.

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PHOTOVOLTAIC ROOF TILE

TECHNICAL FIELD

The invention is directed to roof tiles, and, more particularly, to photovoltaic roof tiles that can be attached to a structure to shed water from the structure and generate electricity.

BACKGROUND OF THE INVENTION

Photovoltaic cells convert solar radiation into electricity. Photovoltaic cells, for example, can convert sunlight into electricity through photogalvanic processes. Photovoltaic cells can be made of semi-conductor materials, such as silicon, cadmium sulfide, cadmium telluride or gallium arsenide. In many applications, one or more photovoltaic cells are configured into rigid or flexible arrays.

Photovoltaic cells, for example, have been used in modular solar panels to generate electricity at residential and small commercial buildings. A typical residential solar panel includes an upper panel, a lower panel juxtaposed to the upper panel, and a large number of photovoltaic cells electrically connected to a bus to route the electricity to a junction box or storage device. The photovoltaic cells are generally attached to one of the lower or upper panels. The photovoltaic cells are also generally protected from the environment by sealing the photovoltaic cells to one of the lower or upper panels, or by sealing the lower and upper panels together. The photovoltaic cells, for example, can be mounted to the lower panel and covered with a protective glazing to encapsulate the photovoltaic cells. Modular solar panels are often connected to a house or other building on top of the roof covering materials (e.g., shingles or tiles) such that the modular solar panels are separate from the shingles, shakes, tiles or other types of roof covering materials.

Conventional solar panels, however, may not be desirable because solar panels may not be aesthetically pleasing. Modular solar panels, for example, may be unsightly rectilinear boxes on top of architectural roof coverings. Thus, separate solar panels may reduce the aesthetics of a building.

Conventional solar panels may also cause water damage to a roof of a building. For example, even when flashing or other sealing materials are installed on the roof to stop leaks, modular solar panels may obstruct leaves and other materials. If a large amount of debris collects under a solar panel, water may pool and damage the roof.

To address some of the problems associated with solar panels, several types of solar roof tiles have been developed. Existing solar roof tiles often have a photovoltaic cell in a large or complex structure that is attached to the roof. Existing solar roof tiles are thus a type of roof covering to protect the building from environmental factors. For example, some solar roof tiles have a main body generally shaped into a tile-like roof covering and a photovoltaic cell attached to the main body.

Sanyo Electric Co., Ltd. has developed a particular solar roof tile. In the Sanyo roof tile, a plurality of photovoltaic cells are formed directly on a tile substrate by depositing, patterning and etching layers of materials on the surface of the substrate using sophisticated processes and technology developed for fabricating integrated circuitry in semiconductor devices. The photovoltaic cells are protected from external elements by covering the photovoltaic cells with epoxy resin, ethyl-vinyl acetate, and polyethylene terepthalate. The Sanyo devices accordingly have sophisticated photovoltaic cells that are integral with the substrate, but they apparently do not have a separate top panel over the cells. The Sanyo tiles are individually mounted to a roof in a manner similar to installing traditional ceramic roofing tiles. Although these roof tiles convert solar energy to electricity, they are expensive to manufacture because the technology and equipment to fabricate integrated circuitry is costly to obtain and operate.

SUMMARY OF THE INVENTION

The present invention is directed toward photovoltaic roof tiles for providing a roof covering and generating electricity. In one embodiment, a photovoltaic roof tile includes a plate assembly and a photovoltaic cell. The plate assembly can have a base portion including an inner surface and a face portion having an interior surface

juxtaposed to the inner surface of the base portion. The inner and interior surfaces are configured to define a compartment, and the photovoltaic cell is positioned in the compartment to receive solar energy. The photovoltaic cell is preferably a separate component sized to at least substantially occupy the compartment. The photovoltaic cell can be rigid or flexible to fit in the component. For example, if the compartment is flat, either a rigid or a flexible photovoltaic cell can be inserted into the compartment. On the other hand, if the compartment is curved (*e.g.*, Spanish Tiles), a flexible cell can be inserted into the compartment to conform to the shape of the compartment. The compartment is also sealed to isolate the cell from the external environment.

The base portion is preferably separate from the face portion. In this embodiment, the base portion is preferably sealed to the face portion with a glass frit, an adhesive, or a glass weld. The base portion can also be sealed to the face portion with a tongue and groove. The base portion and face portion, however, can be integral with the face portion.

The plate assembly is configured to be coupled to a substructure of a roof. For example, the base portion can directly engage the roof substructure, and the base portion and/or the face portion can be fastened directly to the roof substructure. In a typical application, a number of plate assemblies are coupled to the substructure such that each sequential row of plate assemblies partially overlaps an immediately lower row. Additionally, one side of each plate assembly can overlap an adjacent plate assembly, and an opposing side of the one plate assembly can be overlapped by another adjacent plate assembly. The plate assemblies can be interconnected to collectively generate electricity.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an isometric view of a roof substructure and a plurality of photovoltaic roof tiles according to an embodiment of the invention.

Figure 2 is an exploded side elevation view the roof tile of Figure 1.

Figure 3 is a top isometric view of a base portion the roof tile of Figure 1.

Figure 4 is a bottom isometric view of a face portion of the roof tile of Figure 1.

Figure 5 is an isometric view of a roof tile according to another embodiment of the invention.

Figure 6 is a top cross-sectional plan view of the roof tile of Figure 5 viewed along Section 6-6 illustrating a base portion of the roof tile.

Figure 7 is a bottom cross-sectional plan view of the roof tile of Figure 5 viewed along Section 7-7 illustrating a face portion of the roof tile.

Figure 8 is a plan view of a photovoltaic cell of the roof tile of Figure 5.

Figure 9 is an isometric view of a roof tile according to yet another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is generally directed toward photovoltaic roof tiles or shingles that can be mounted to a roof substructure to protect the substructure and generate electricity. Many specific details of certain embodiments of the invention are set forth in the following description and in Figures 1-9 to provide a thorough understanding of such embodiments. One skilled in the art, however, will understand that the present invention may have additional embodiments, or that the invention may be practiced without several of the details described in the following description.

Figures 1 illustrates a plurality of photovoltaic roof tiles 116 in accordance with one embodiment of the invention. In this embodiment, each roof tile 116 includes a plate assembly 118 configured to be mounted to a roof substructure 121 and a photovoltaic cell 120 encapsulated in the plate assembly 118. The roof tiles 116 are generally arranged in rows such that one row overlaps a portion of an immediately adjacent lower row. The photovoltaic cells 120 can be electrically interconnected to a bus to generate electricity for immediate use or storage. As such, the roof tiles 116 form a roof covering that protects the substructure 121 and generates electricity.

Figures 2-4 illustrate the roof tile 116 in greater detail. As illustrated in Figure 2, the plate assembly 118 can have a base portion 122 and a separate face portion

124. The base portion 122 is configured to be coupled to the substructure 121 (Figure 1) and to support the photovoltaic cell 120. The face portion 124 is configured to engage the base portion 122 and to retain a photovoltaic cell 120. The face portion 124 accordingly protects the photovoltaic cell 120.

Referring to Figure 3, the base portion 122 is preferably a flat, rectilinear plate. The base portion 122 has a first end 136 and an opposing second end 138; a first side margin 123 and an opposing second side margin 125; and a bottom surface 128 and an inner surface 130. When the roof tile 116 (Figure 1) is attached to the substructure 121, the bottom surface 128 of the base portion 122 preferably rests directly on the substructure 121, and the second end 138 of the base portion 122 is directed toward a high point on the structure (*e.g.*, a ridge). The base portion 122 is preferably fabricated from a strong, substantially rigid material, such as metal, plastic, ceramic, glass or other suitable material.

The inner surface 130 of the base portion 122 can be flat, and it has a first recess 131 for receiving at least a portion of the photovoltaic cell 120 (Figure 2). The inner surface 130 can also be reflective or have a black finish. In the illustrated embodiment, the first recess 131 has a depth approximately equal to one-half of the thickness of the photovoltaic cell 120. The first recess 131, however, can be textured or curved, and it can be deeper or shallower to suit the requirements of a specific situation. The first recess 131 can also be coated with an adhesive to fixedly attach the photovoltaic cell 120 to the base portion 122.

The base portion 122 also has a sealing ridge 133 projecting from the inner surface 130 and surrounding at least a portion of the first recess 131. The sealing ridge 133 is preferably substantially continuous to enhance the seal around the photovoltaic cell 120. The sealing ridge 133 can be integral with the base portion 122, or it can be a separate element adhered the base portion 122. In the illustrated embodiment, the sealing ridge 133 has a square cross-section, but it may alternatively have a variety of cross-sectional shapes (*e.g.*, curved or polygonal). The sealing ridge 133 may be cut by a groove 152 in the inner surface 130 to receive one or more electrical leads 148 (Figure 2) projecting from the photovoltaic cell 120 (Figure 2).

The base portion 122 also preferably has at least one engagement ridge 135 projecting from the inner surface 130. The engagement ridges 135 are preferably elongated ridges having semi-circular cross-sections that extend from the first end 136 of the base portion 122 to the second end 138. The engagement ridges 135 are also positioned outside of the sealing ridge 133 near the second side margin 125. The engagement ridges 135 can have an arcuate cross-section (shown in Figure 3), or they can have a variety of other cross-sectional shapes (*e.g.*, curved or polygonal). In this embodiment, the engagement ridges 135 are integral with the base portion 122, but they can also be separate elements that are adhered to the base portion 122. As illustrated in Figure 1, and discussed in detail below, the engagement ridges 135 engage complementary grooves or other features on an adjacent roof tile to channel water off of the substructure 121.

The base portion 122 is configured to be mounted directly onto the roof substructure 121. In this embodiment, the bottom surface 128 of the base portion 122 has a pair of opposing mounting projections 137 in which one mounting projection 137 is at the first end 136 and the other mounting projection 137 is at the second end 138. The size and shape of the mounting projections 137 can be varied to adjust the distance between the bottom surface 128 and the structure 121. The base portion 122 also has at least one first hole 151 for receiving a fastener (not shown). The first holes 151 are positioned near the second end 138, and they extend from the inner surface 130 to the bottom surface 128. As explained in more detail below, the mounting projections 137 and the first holes 151 operate together so that the base portion 122 can be attached to the substructure 121 to create a roof covering.

Figure 4 illustrates the bottom side of the face portion 124 in greater detail. In this embodiment, the face portion 124 has a top surface 132 and an interior surface 134. The interior surface 134 of the face portion 124 is configured to engage the inner surface 130 of the base portion 122 (Figure 3). The face portion 124 also can include a first end 136 and a second end 138, and a first side margin 123 and a second side margin 125. When the face portion 124 is attached to the base portion 122, the first and second ends 136 and 138 are preferably aligned with each other (Figure 1), but the

first and second side margins 123 and 125 are preferably offset from one another (Figure 2). Additionally, when positioned for use, as shown in Figure 1, the top surface 132 is positioned toward the direction of the sun. The face portion 124, therefore, is preferably made from a translucent material, such as glass, Plexiglas®, or other suitable materials.

The face portion 124 can have a second recess 139 that is at least partially aligned with the first recess 131 on the base portion 122 when the plate assembly 118 is assembled (Figure 2). In the illustrated embodiment, the second recess 139 preferably has a flat surface and a depth approximately equal to one-half of the thickness of the photovoltaic cell 120 (Figure 2). The second recess 139 can alternatively be textured or curved, and it can be deeper or shallower to suit the requirements of a specific situation.

When the plate assembly 118 is assembled, as best illustrated in Figure 2, the first recess 131 and the second recess 139 form a compartment 126 to contain the photovoltaic cell 120. The first and second recesses 131, 139 are preferably configured to closely receive the photovoltaic cell 120, but these recesses can be deeper to allow air or inert gases to circulate around the cell. The compartment 126 can also be sufficiently larger than the photovoltaic cell 120 such that at least one of the inner surface 130 and interior surface 134 is not flat. For example, the inner surface 130 of the base portion 122 may be flat and the interior surface 134 of the face portion 124 may be a curved surface spaced apart from the photovoltaic cell 120. The face portion 124, therefore, can be a lens that focuses solar energy onto the photovoltaic cell 120.

Referring to Figures 2 and 4, the face portion 124 also has a sealing groove 141 surrounding the second recess 139 for receiving the sealing ridge 133 on the base portion 122 (Figure 2). The sealing groove 141 is accordingly slightly larger than the sealing ridge 133, and the sealing groove 141 preferably has a shape similar to the sealing ridge 133. In the illustrated embodiment, the sealing groove 141 has a rectangular cross-section, but the sealing groove 141 can have a variety of cross-sectional shapes (*e.g.*, circular or polygonal). The sealing groove 141 can also be

coated with a sealant, or lined with a gasket material, to aid in sealing the photovoltaic cell 120 from the external environment.

The face portion 124 also has at least one engagement groove 143 along its first side margin 123. In this embodiment, the engagement grooves 143 are elongated, linear grooves having semi-circular cross-sections that are complementary in size and shape to the engagement ridges 135 on the base portion 122 (Figure 2). The engagement grooves 143, however, are positioned along the first side margin 123 of the face portion 124, whereas the engagement ridges 135 are positioned along the second side margin 125 of the base portion 122. Thus, as illustrated in Figure 1, the engagement ridges 135 of a first roof tile 116a are received by the engagement grooves 143 in the face portion 124 of a second roof tile 116b immediately adjacent to one side of the first roof tile 116a.

The face portion 124 also has at least one second hole 153 for receiving a fastener (not shown) for mounting the tile 116 to the substructure 121. The second holes 153 are positioned to be aligned with the first holes 151 in the base portion 122 (Figure 2) such that, when the face portion 124 is engaged with the base portion 122, a single fastener can extend through both the first and second holes 151 and 153. The face portion 124 can alternatively be designed with notches or recesses to expose the first holes 151 to allow the tile 116 to be mounted to the substructure 121.

The photovoltaic cell 120 is sized and shaped to fit within the compartment 126. As a result, the photo-voltaic cell 120 is preferably a commercially-available component that can be readily purchased to accommodate a particular application without being limited to expensive semiconductor manufacturing processes. In the illustrated embodiment, the photovoltaic cell 120 is a flat and smooth unit (Figure 2), and it can be rigid or flexible. On the other hand, if the compartment 126 is curved, the photovoltaic cell 120 can be flexible to conform to the shape of the compartment 126.

Figure 2 best illustrates one method for assembling the roof tile 116. In this embodiment, the photovoltaic cell 120 is positioned in the first recess 131 and the leads 148 pass through the groove 152. The face portion 124 is then placed on the base

portion 122 to insert the sealing ridge 133 in the sealing groove 141. The base portion 122 and face portion 124 are preferably pressed together until the inner surface 130 of the base portion 122 contacts the interior surface 134 of the face portion 124. The perimeter of the plate assembly 118 between the base portion 122 and the face portion 124 is then sealed to encapsulate the photovoltaic cell 120 in the compartment.

The base portion 122 can be sealed to the face portion 124 around the perimeter of the inner and interior surfaces 130 and 134, and/or around the sealing ridge 133 and the sealing groove 141. In one embodiment, the base portion 122 is sealed to the face portion 124 by heating a glass frit to a melting temperature below the melting temperatures of the base and face portions. In another embodiment, a laser melts the base and face portions 122 and 124 together around the perimeter of the joint between these portions. In still another embodiment, a silicon adhesive or another suitable adhesive is applied to the inner and interior surfaces 130 and 134 to seal and adhere the base portion 122 to the face portion 124.

To construct a roof covering from a plurality of the tiles 116, each tile 116 is oriented with the face portion 124 directed upward and installed in a manner similar to hanging traditional roof tiles. As illustrated in Figure 1, the substructure 121 preferably has a plurality of tacking strips 147 spaced apart from one another over plywood or composite roofing sheets 149. A first row 145 of tiles 116 is placed along a bottom edge of the substructure 121 so that a mounting projection 137 at the second end 138 of each tile 116 hooks onto the lowest tacking strip 147. The tiles 116 on the first row 145 also preferably overlap one another such that the first margin of a face portion 124 of one tile (*e.g.*, 116b) overlaps the second margin 125 of a base portion 122 of an immediately adjacent tile to the right-side (*e.g.*, 116a). A second row of tiles 116 can then be attached to the substructure 121 to overlap the second ends 138 of the tiles 116 in the first row 145. As each row of tiles 116 is installed on the substructure 121, the leads 148 are connected to a bus 155. The buses 155 for each row are then interconnected to direct the combined electricity generated by the tiles 116 to a central location. When the tiles 116 have been installed, the tiles 116 define a roof covering and a solar panel.

The roof tile 116 shown in Figures 1-4 is expected to be less expensive and provide more design options than existing solar roof tiles. One aspect of this embodiment of the roof tile is that a simple three-piece assembly provides a roof covering and a solar panel in a single unit. Another aspect of this embodiment is that the photovoltaic cell can be a commercially available unit that is simply inserted into the plate assembly. Thus, unlike existing solar tiles that use complex semiconductor photovoltaic cells or complex housings to hold such cells, this particular embodiment of the roof tile is expected to be a simple, flexible unit that can be inexpensively manufactured and installed.

Figures 5-8 illustrate another embodiment of a photovoltaic roof tile 216 of the present invention. In this embodiment, the roof tile 216 includes an integral plate assembly 218 having a base portion 222, a face portion 224 integral with the base portion 222, and a compartment 226 between the base portion 222 and the face portion 224. The compartment 226 is sized to receive the photovoltaic cell 220. In the illustrated embodiment, the compartment 226 is a rectilinear cavity. The compartment 226 can be formed by etching a glass block or molding glass around a removable/disposable insert. The compartment 226 can accordingly have a distal edge 240 at a second end 238 of the plate assembly 218, and side edges 242 extending from a first end 236 of the plate assembly 218 to the distal edge 240. The compartment 226 is accordingly open at the first end 236 of the plate assembly 218 to receive the photovoltaic cell 220.

The open end of the compartment 226 is sealed to protect the photovoltaic cell 220. The compartment 226, for example, can be sealed by a plug 244 configured to be closely received by the opening of the compartment 226. The plug 244 can be attached to the plate assembly 218 with an adhesive, such as silicone, or by sealing the edge of the plug 244 with glass frit.

The plate assembly 218 also has an opening 246 extending from the distal edge 240 of the compartment 226 to the second end 238 of the plate assembly 218. The opening 246 can alternatively extend from one of the side edges 242 or pass through the plug 244. The opening 246 is sized to receive a pair of leads 248 projecting

from the photovoltaic cell 220, and the opening 246 is preferably sealed around the leads 248. Once the plug 244 is sealed at the first end 236 of the plate assembly 218 and the opening 246 is sealed at the second end 238 of the plate assembly, the photovoltaic cell 220 is completely sealed within the compartment 226.

The plate assembly 218 also has a plurality of holes 250 near the second end 238 to mount the tile 216 to the substructure 221. The holes 250 extend from a top surface 232 to a bottom surface 228 to allow a fastener, such as a nail, to pass though the tile 216 and into a substructure 221. Although Figure 5 shows holes 250 for receiving a fastener to attach the tile 216 to the substructure 221, the tile 216 could also be retained to the substructure 221 using tabs projecting from the bottom surface 228, an adhesive, or any other suitable mounting means. The bottom surface 228 of the tile 216, for example, can be glued to a flexible sheet, such as roofing material, which is in turn fastened to the substructure 221.

The photovoltaic cell 220 is sized and shaped to fit within the compartment 226. For most embodiments, traditional, off-the-shelf or commercially-available photovoltaic cells can be used. In the illustrated embodiment, the photovoltaic cell 220 is flat and smooth unit that can be rigid or flexible. Similar to the above embodiment, however, the compartment 226 can also be significantly larger than the photovoltaic cell 220, or it can be curved such that the photovoltaic cell 220 conforms to the shape of the compartment 226.

Figure 9 illustrates yet another photovoltaic roof tile according to the present invention. This embodiment is similar to the embodiment described with respect to Figures 5-8, and reference numbers with the same last two digits refer to similar components. The tile 316, however, does not have engagement ridges or engagement grooves.

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

1. A photovoltaic roof tile, comprising:

a plate assembly including a base portion and a face portion, the base portion having an inner surface and the face portion having an interior surface juxtaposed to the inner surface of the base portion, the inner and interior surfaces being configured to define a compartment between the base portion and the face portion, the compartment being sealed, and the plate assembly being configured to be coupled directly to a roof substructure and to overlap at least one adjacent roof tile for directing water down a slope of the roof; and

a photovoltaic cell in the compartment, the photovoltaic cell being sized to at least substantially occupy the compartment.

2. The tile of claim 1, wherein the plate assembly includes at least one hole for receiving a fastener to couple the tile to the roof substructure.

3. The tile of claim 1, further comprising a flexible mounting member attached to the tile, the mounting member being configured to receive a fastener for coupling the tile to the roof substructure.

4. The tile of claim 1, wherein the cell is flexible to conform to at least one of the inner and interior surfaces.

5. The tile of claim 1, wherein the cell is coupled to at least one of the inner and interior surfaces.

6. The tile of claim 1, wherein a bottom surface of the assembly has a downward projection configured to engage a complementary mounting projection on the structure to retain the tile on the substructure.

7. The tile of claim 1, wherein the photovoltaic cell has at least one electrical lead and the tile is configured to allow the lead to extend from the compartment and project from the tile.

8. The tile of claim 1, wherein the base portion has a first margin and an opposing second margin and the face portion has corresponding first and second margins, and wherein the first margin of the face portion projects beyond the first margin of the base portion and the second margin of the base portion projects beyond the second margin of the face portion such that a first margin of a face portion of a first tile will overlap a second margin of a base portion of an adjacent second tile.

9. The tile of claim 8, wherein the first margin of the face portion has a first engagement element and the second margin of the base portion has a complementary second engagement element, the first and second engagement elements interlocking when the first tile is positioned adjacent the second tile.

10. The tile of claim 1, wherein the base portion and face portion are separate portions, and the face portion is sealingly attached to the base portion.

11. The tile of claim 10, wherein the inner surface of the base portion has a recess sized to receive the cell.

12. The tile of claim 10, wherein the base portion has at least one hole for receiving a fastener to couple the assembly to the substructure.

13. The tile of claim 10, wherein the base portion has at least one first hole and the face portion has at least one second hole positioned to align with the first hole when the face portion is engaged with the base portion, the first and second holes being sized to receive a fastener for coupling the tile to the substructure.

14. The tile of claim 10, wherein the base portion further comprises a sealing ridge positioned to surround the cell when the cell is engaged with the base portion, and the face portion further comprises a complementary sealing groove positioned to receive the sealing ridge when the face portion is engaged with the base portion.

15. The tile of claim 10, wherein the face portion is sealed to the base portion with glass fritting.

16. The tile of claim 10, wherein the face portion is sealed to the base portion with rubber.

17. The tile of claim 16, wherein the rubber is silicone.

18. A roof tile for protecting a substructure from water damage, and for converting solar energy to electrical energy, the tile comprising:

a photovoltaic array;

a base portion having an inner surface, the base portion being configured to mount directly to the substructure, and the photovoltaic array being supported by the inner surface; and

a face portion having an interior surface configured to engage the base and to closely receive the photovoltaic array between the inner and interior surfaces, the face portion having a translucent section aligned with the photovoltaic array and the face portion being sealed to the base portion to isolate the photovoltaic array from an external environment, the face portion, the photovoltaic array and the base portion collectively defining a roof tile assembly having a bottom surface configured to be coupled to the substructure and being configured to overlap an adjacent assembly to direct water off of the substructure.

19. The roof tile of claim 18, wherein the base portion has at least one hole for receiving a fastener to couple the roof tile assembly to the substructure.

20. The roof tile of claim 18, wherein the base portion has at least one first hole and the face portion has at least one second hole aligned with the first hole when the face portion is engaged with the base, the first and second holes being sized to receive a fastener for coupling the roof tile assembly to the substructure.

21. The roof tile of claim 18, further comprising a flexible member connected to the roof tile assembly, the flexible member being configured to receive at least one fastener for coupling the roof tile assembly to the substructure.

22. The roof tile of claim 18. wherein the bottom surface of the roof tile assembly has a downward projection oriented to engage a complementary mounting projection on the structure to retain the roof tile assembly on the substructure.

23. The roof tile of claim 18. wherein the inner surface of the base portion has a recess sized to receive the photovoltaic array.

24. The roof tile of claim 23, wherein the photovoltaic array has at least one electrical lead and the base portion is configured to allow the lead to extend from the recess and project externally from the roof tile assembly.

25. The roof tile of claim 24, further comprising a groove extending from the recess to a terminal edge of the base for receiving the lead.

26. The roof tile of claim 1, wherein the base portion has a first margin and an opposing second margin and the face portion has corresponding first and second margins, and wherein the face portion is engaged with the base portion such that the first margin of the face portion projects beyond the first margin of the base portion and the second margin of the base portion projects beyond the second margin of the face portion such that a first margin of a face portion of a first roof tile will overlap a second margin of a base portion of an adjacent second roof tile.

27. The roof tile of claim 26, wherein the first margin of the face portion has a first engagement element and the second margin of the base portion has a complementary second engagement element, the first and second engagement elements interlocking when the first roof tile is positioned adjacent the second roof tile.

28. The roof tile of claim 1, wherein the base portion further comprises a sealing ridge positioned to surround the photovoltaic array when the photovoltaic array is engaged with the base portion, and the face portion further comprises a complementary sealing groove positioned to receive the ridge when the face portion is engaged with the base portion.

29. The roof tile of claim 1, wherein the face portion is sealed to the base with glass fritting.

30. The roof tile of claim 1, wherein the face portion is sealed to the base with rubber.

31. The roof tile of claim 30, wherein the rubber is silicone.

32. A photovoltaic roof tile system comprising:

a roof substructure;

a plurality of roof tile assemblies, each assembly having a base portion, a photovoltaic array, and a face portion, the base portion having an inner surface configured to receive the photovoltaic array, the face portion having an interior surface configured to closely retain the photovoltaic array with respect to the inner surface of the base portion, the face portion having a translucent portion aligned with the array, the face portion being sealed to the base portion to isolate the photovoltaic array from an external environment, each roof tile assembly having a bottom surface configured to be coupled to the substructure and to overlap an adjacent assembly to direct water off of the structure, and

at least one connector for electrically interconnecting the roof tile assemblies.

33. The system of claim 32, further comprising a mounting strip attached to the substructure and wherein the bottom surface of the roof tile assembly has a downward projection oriented to engage the mounting strip and retain the assembly on the substructure.

34. The system of claim 32, wherein each roof tile assembly has a first side margin and an opposing second side margin, a first side margin on a first roof tile assembly configured to engage a second side margin on an adjacent second roof tile assembly.

35. The system of claim 34, wherein the first side margin of each roof tile assembly has a first engagement element and the second side margin of each assembly has a complementary second engagement element, the first and second engagement elements interlocking when a first roof tile assembly is positioned adjacent a second roof tile assembly.

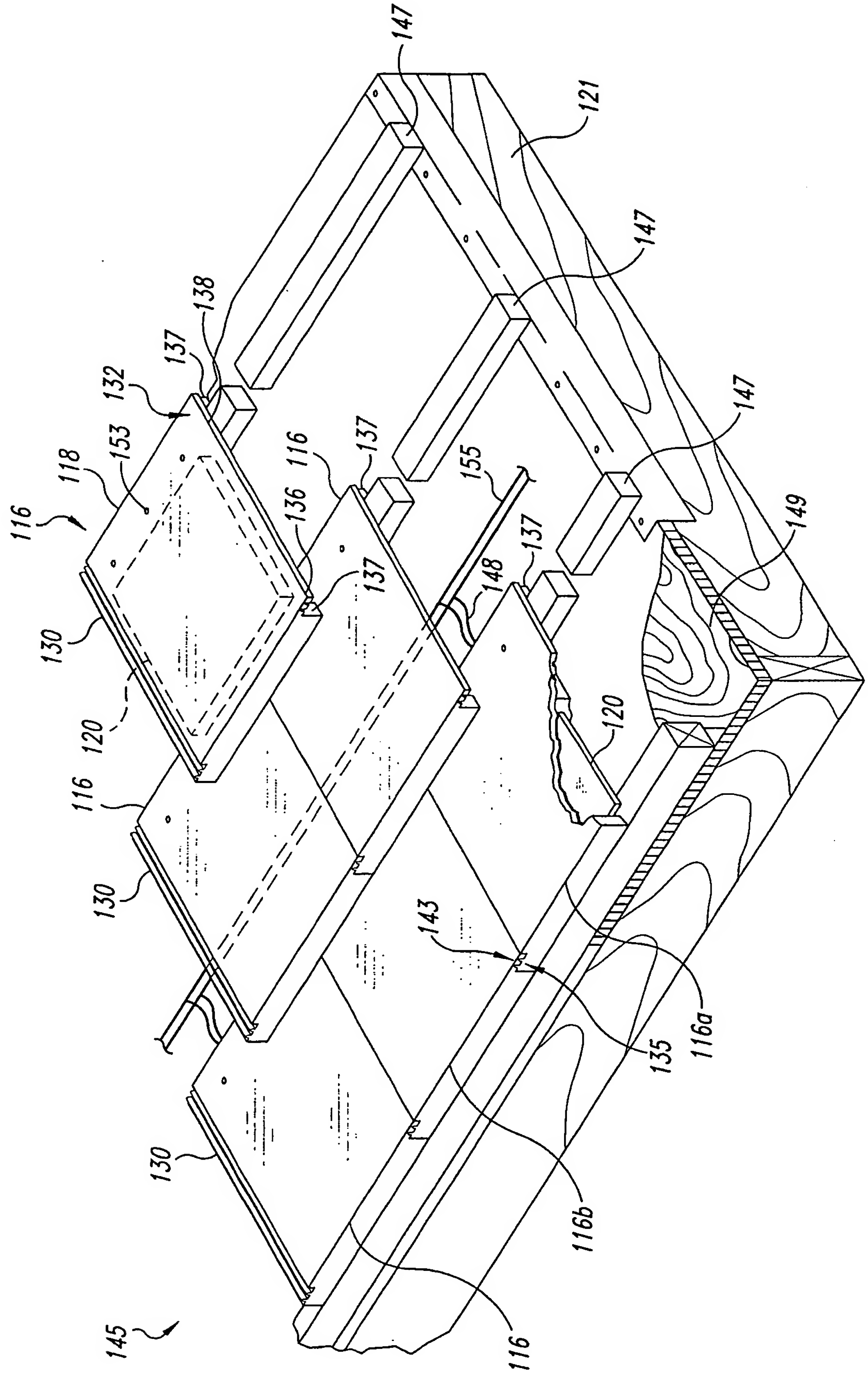
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Fig. 1

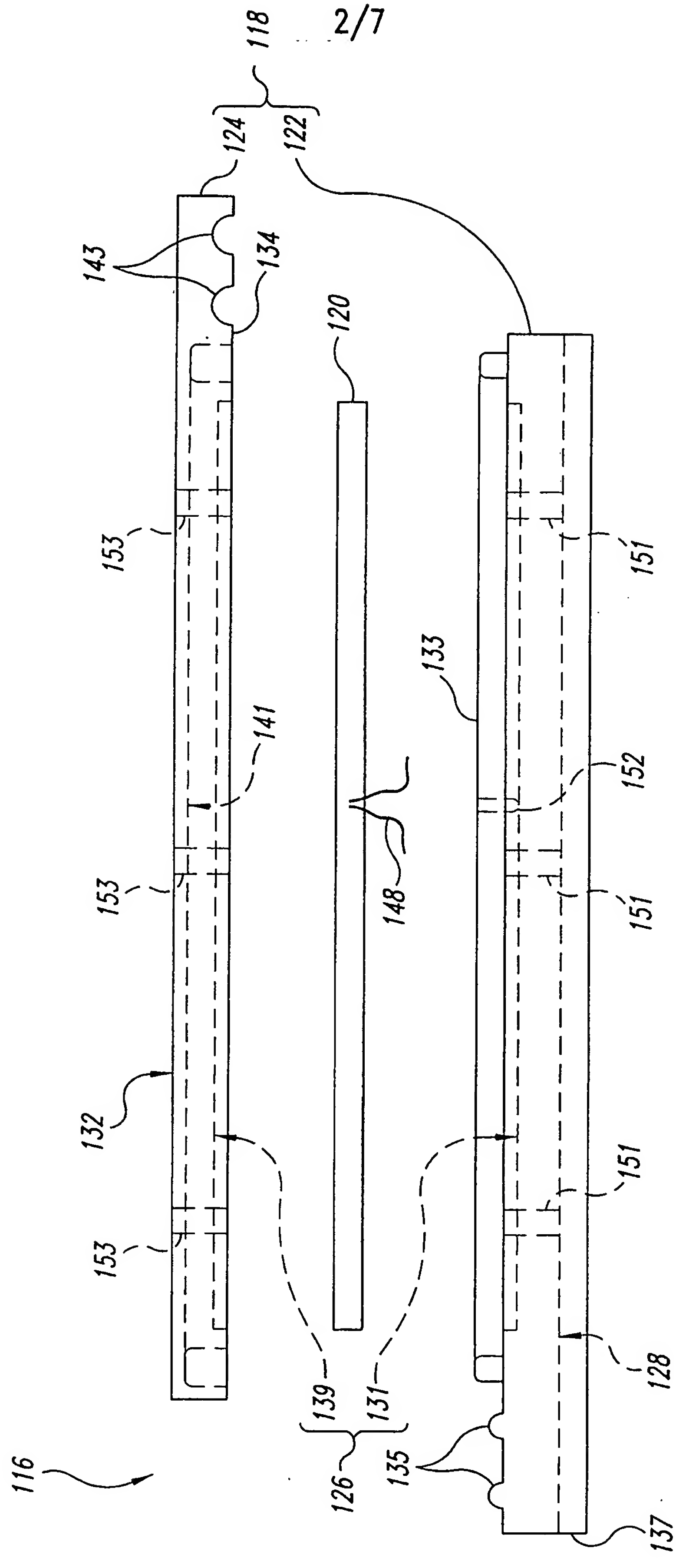
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Fig. 2

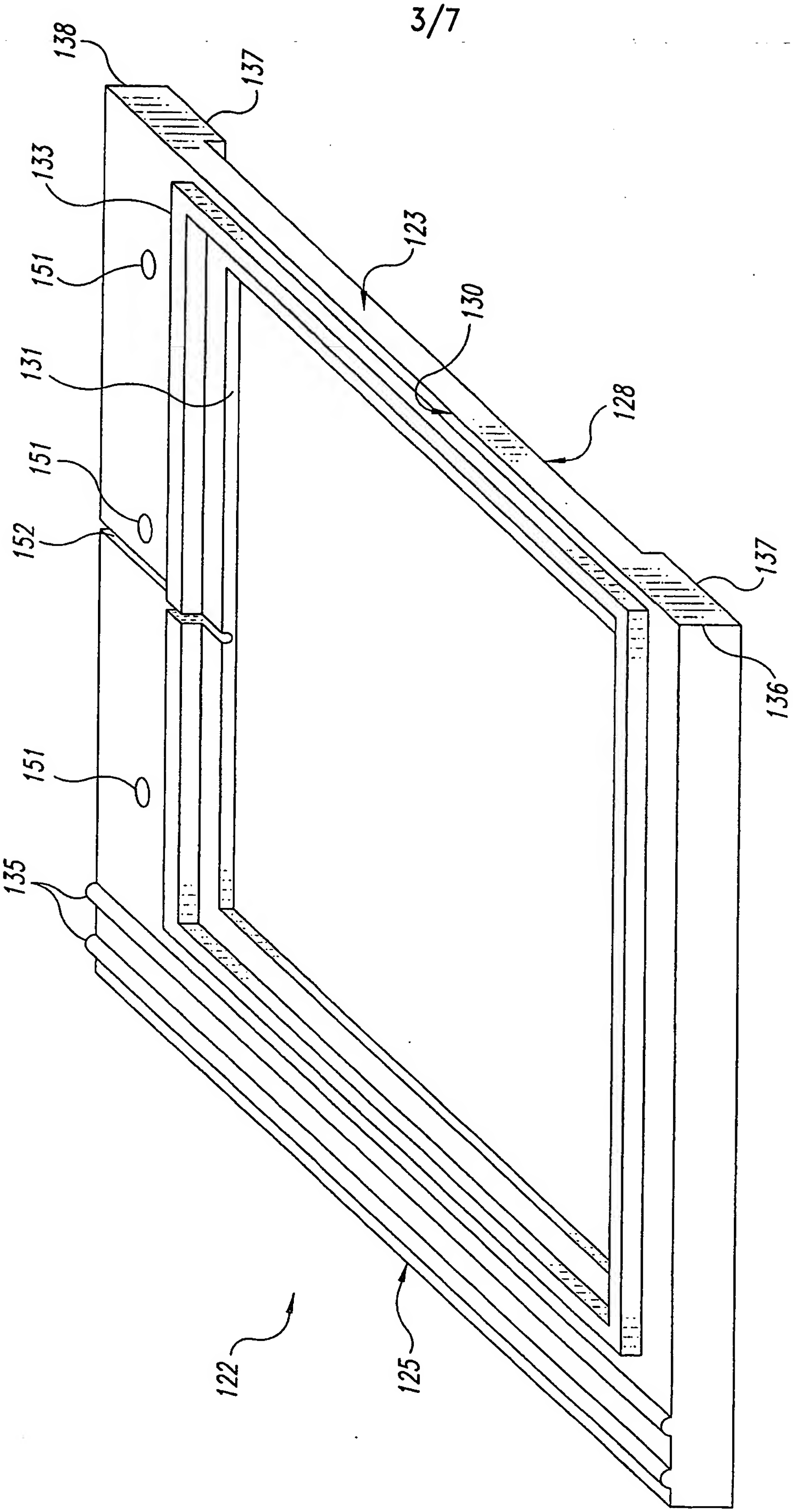

Fig. 3

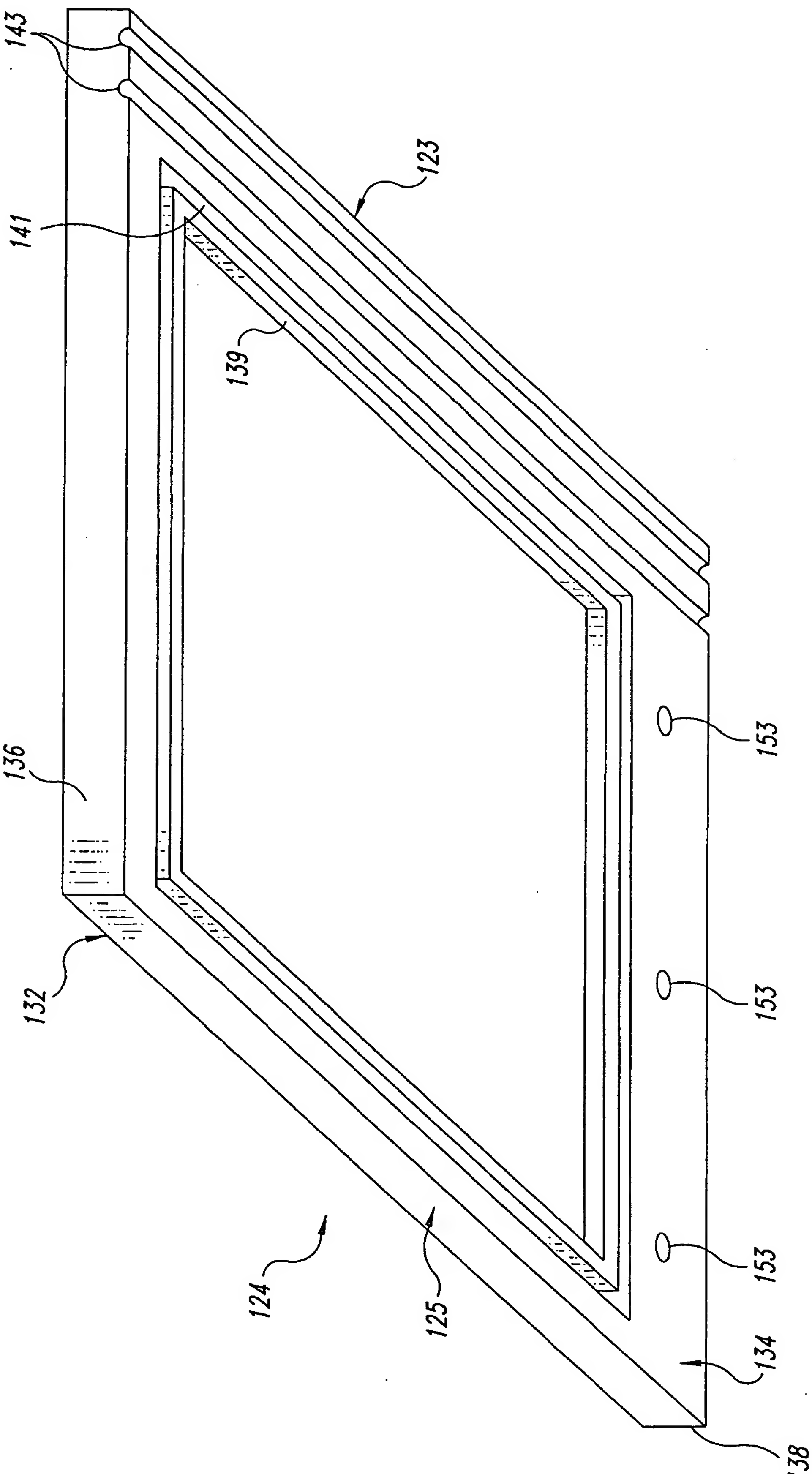

Fig. 4

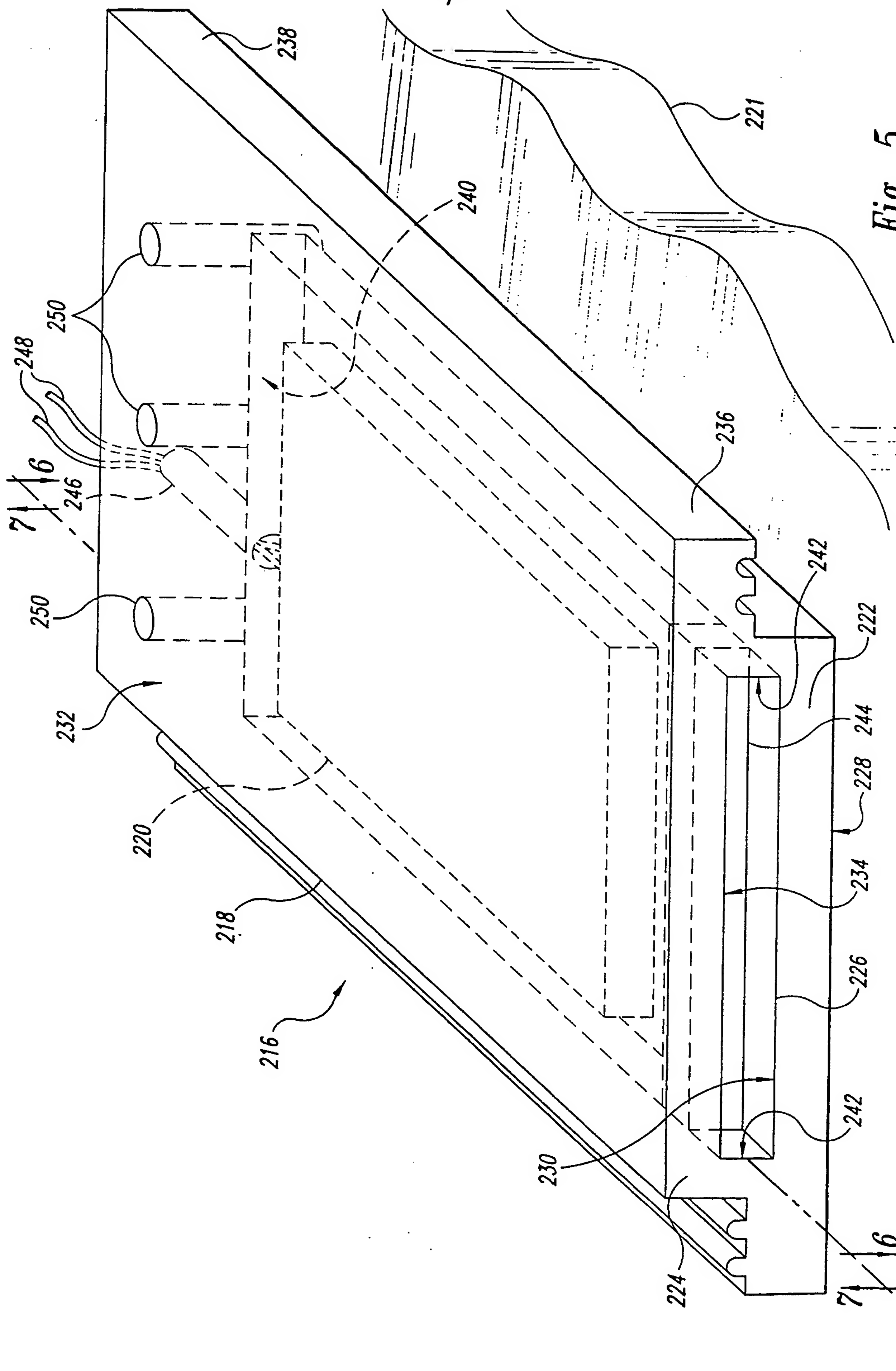
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Fig. 5

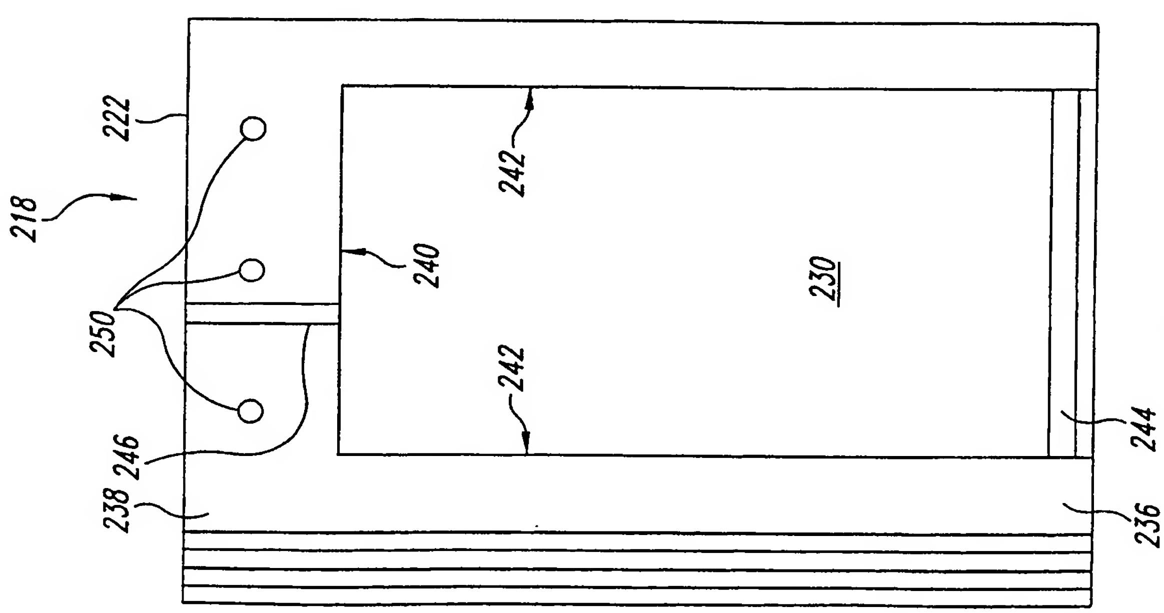

Fig. 6

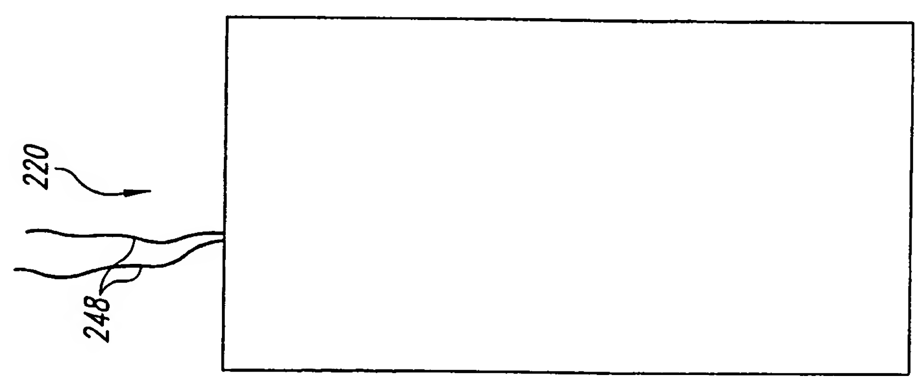

Fig. 8

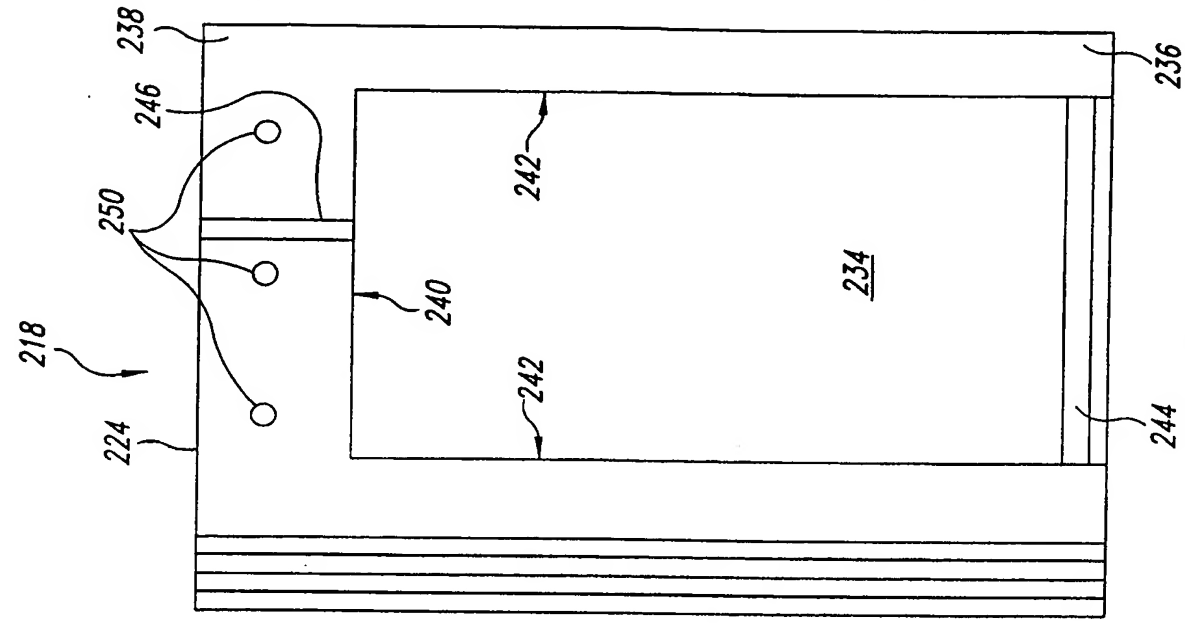

Fig. 7

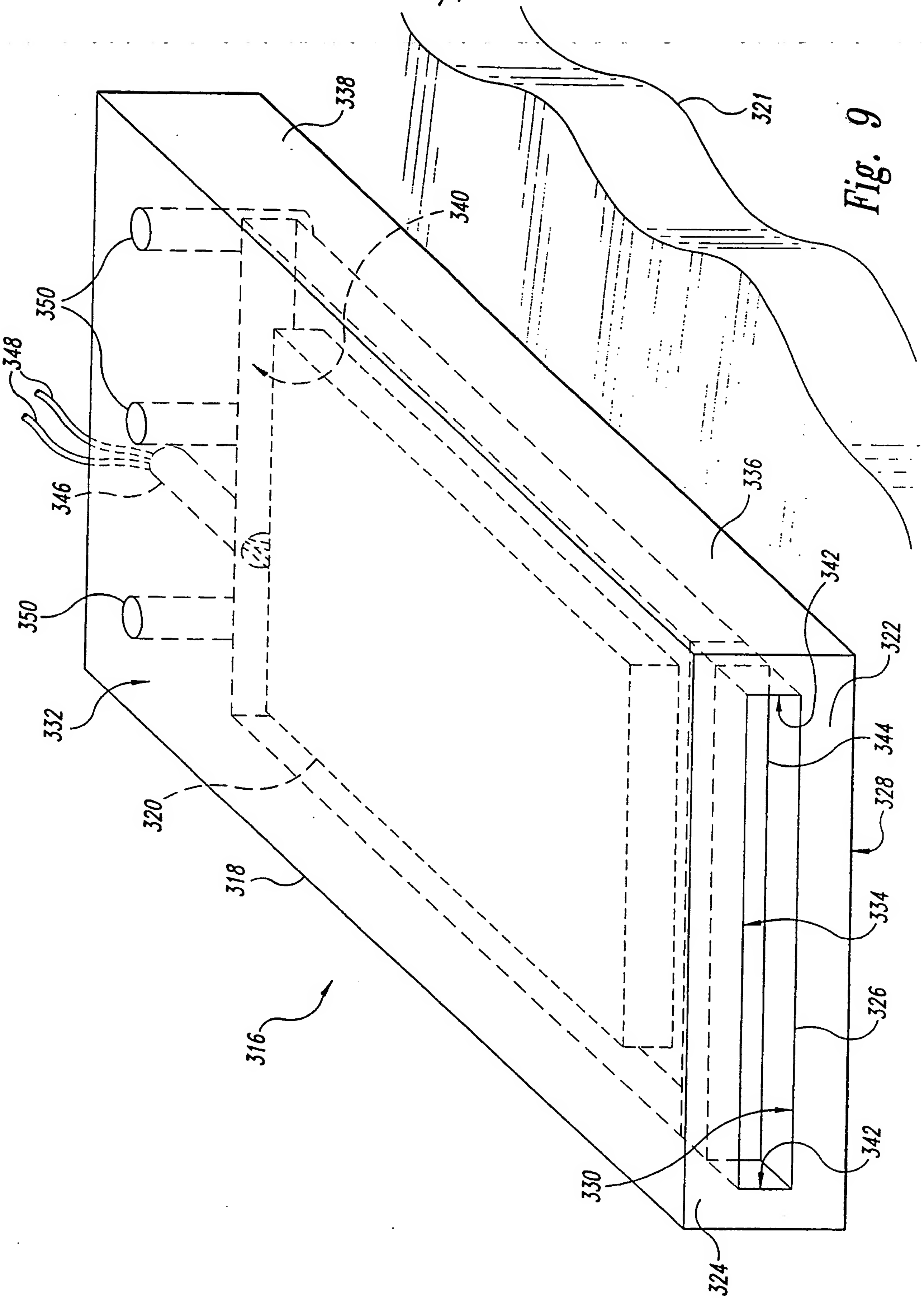
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Fig. 9

INTERNATIONAL SEARCH REPORT

Intern. ...al Application No
PCT/US 99/27175

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L31/048 E04D13/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 671 (M-1726), 19 December 1994 (1994-12-19) & JP 06 264571 A (GANTAN BEAUTY KOGYO KK), 20 September 1994 (1994-09-20) abstract ---	1,5,7,8, 18,23, 24,32
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A	DE 32 47 468 A (IMCHEMIE KUNSTSTOFF GMBH) 12 July 1984 (1984-07-12) the whole document --- -/--	1,5,7, 11,18, 23,32

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 April 2000	02/05/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Visentin, A

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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